Effects of Intercropping Beans and Onions on Populations of *Liriomyza* spp. and Associated Parasitic Hymenoptera[1]

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ABSTRACT

Surveys of commerical plantings and experimental studies on onions were conducted in the Kula area of Maui to provide information on the *Liriomyza* species and their parasites inhabiting the crop. *Liriomyza huidobrensis* (Blanchard) (95.7%) and *L. trifolii* (Burgess) (4.2%) were the predominant species found infesting the onions in commercial plantings. *L. sativae* Blanchard was occasionally recorded. The major parasite species reared from leafminers collected from onions were *Halticoptera circulus* (Walker) and *Chrysocharis parksi* Crawford. Attempts to augment parasitization of leafminers infesting onions by planting adjacent bean borders for production of leafminer parasites were unsuccessful due to several factors which are discussed.

Bulb onion production in the state of Hawaii is concentrated on the slopes of Haleakala in the Kula area between the elevations of 420 and 1040 m. In 1982, total bulb onion production in Hawaii was valued at ca. 894,000 dollars (Anonymous 1983). Early in 1983, growers in the Kula area experienced unusually high densities of *Liriomyza* spp. infesting their onions. Attempts at leafminer control resulted in more frequent applications of insecticides on the onion plantings. Some onion plantings were terminated prior to harvest because of intensive mining damage.

In the Kula area, *Liriomyza sativae* Blanchard, *L. trifolii* (Burgess), and *L. huidobrensis* (Blanchard) are known to occur on various vegetable crops. No intensive studies have been conducted with respect to the leafminer parasite fauna present in the area. However, several species have been introduced for leafminer control by the Entomology Branch, Hawaii Department of Agriculture. These species include *Chrysonotomyia punctiventris* (Crawford), *Chrysocharis parksi* Crawford, *Diglyphus intermedius* (Girault), *Opius dissitus* Muesebeck, and *Ganaspidium hunteri* Crawford (= *Ganaspidium* n. sp.) (Nakao and Funasaki 1979, Nakao et al. 1981). Several studies (Hills and Taylor 1951, Harding 1965, Oatman 1959, Johnson et al. 1980) have shown that *Liriomyza* spp. are usually heavily parasitized in the absence of insecticide applications. Mothershead (1978) reported eleven species of parasites reared from *Liriomyza* spp. on Oahu.

Principle parasites regulating *Liriomyza* populations may differ between crops and geographical areas (Oatman and Johnson 1981). Zehnder and Trumble (1984) showed that relative abundances of leafminer parasite species may vary with respect to leafminer species and host crop when crops are adjacent. No attempts of parasite augmentation have been reported by the use of intercropping to increase parasite densities in a given area.

The objectives of the study reported herein were to identify and assess the leafminer populations and their parasites in commercial onion plantings in the Kula area; determine the potential of intercropping bush bean strips adjacent to onion

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plantings for parasite augmentation; and examine the effects of a broad-spectrum insecticide on leafminer populations infesting onions.

MATERIALS AND METHODS

Experimental field studies were conducted at the Pulehu site of the Univ. of Hawaii's Maui Branch Station, Kula, Maui, Hawaii. Commercial onion plantings surveyed were located in the Kula area between 500 and 1040 m in elevation. All onion leaves sampled with respect to leafminer densities were selected from the five tallest leaves per plant. Leaves were removed from the plant at their base. Onion leaves were taken to the laboratory at the University of Hawaii, Honolulu, where leaf lengths and base widths were recorded. Leaves were examined under a dissecting microscope for live *Liriomyza* larvae and parasitized larvae. After examination, leaves were placed in emergence containers similar to those described by Johnson et al. (1980). After 3 wk, emerged insects were identified and recorded.

Experimental Field Studies

Onion plants, 'Yellow Granites' variety (Desert Seed Co., El Centro, CA), were transplanted on June 7, 1983 at a density of 143,457 plants/ha. Field plots were arranged in a randomized complete block design with 4 replicates, and consisted of 8 rows 10.7-m long on 0.46-m centers with 2.7-m buffer spaces on each replicated side. Two experimental treatments were examined. The first was the effect of planting bean-borders adjacent to the onion replicates prior to the transplanting of the onions. This was to build-up a leafminer population in the beans which would produce parasites for augmentation in the onion replicates. 'Green Crop' bush beans (Honolulu Seed Co., Honolulu, HI) were grown to the 2-leaf stage in the green house and then transplanted on May 24 and July 27 in three rows (double row beds) adjacent to each side of the onion replicates. After transplanting on May 24, beans were treated with dimethoate at 0.56 kg Active Ingredient/ha on May 26 to control the bean fly, *Ophiomya phaseoli* (Tryon). Bean borders were treated with applications of methomyl at 1.0 kg AI/ha on May 26 and June 6 to increase *Liriomyza* densities by suppression of effective parasites (Johnson et al. 1980, Waddill 1978). The second experimental treatment consisted of weekly applications of methomyl at 1.0 kg AI/ha from June 14 to July 28. All insecticides were applied with a CO_2 charged backpack sprayer equipped with a single No. 962504 fan nozzle at 2.11 kg/cm^2, delivering 560 liters water/ha. The described treatments were compared with an untreated control. All onion replicates were treated with diazinon at 1.12 kg AI/ha on July 14 for control of onion thrips, *Thrips tabaci* Lindeman.

Twenty onion leaves were sampled from the outer 3 rows (6 rows total) of each replicate. Samples were taken on June 16, 21, 28, July 13, 19, 27, Aug. 10 and 23. Twenty mature bean leaves were sampled from the bean borders on the same dates.

Estimates of total leaf area per plant were made from measurements of leaf length and base width of each leaf per sampled plant. Measurements were recorded on June 15, 21, 28, July 12, 19, 27, Aug. 9 and 22. Ten plants were sampled per replicate on and prior to July 12, and five plants thereafter. Early in the development of the onion leaves, they are morphologically similar to elongated cones. As they mature, they change into a half-cone shape. Prior to July 28, estimations of onion leaf areas were calculated using the equation for the lateral surface of a cone (Beyer 1976). Afterwards, estimations were calculated using the equation of one-half the lateral surface of a cone plus the area of the triangle composing the flat side of the leaf.

Onions were harvested on Sept. 12 from the inner two rows of each replicate and were left to cure for one week in the field according to local practices. On Sept. 19, onions were separated and weighed with respect to the following onion width categories: 0–4.0 cm; 4.1–6.0 cm; 6.1–8.0 cm; 8.1–10.0 cm; and 10.1–12.0 cm.

Data were analyzed by an analysis of variance. Mean separations were made by Duncan's multiple range test ($P<0.05$).

Commercial Field Survey

Five commercial plantings were monitored in 1983. These fields will be referred to as Fields, 1, 2, 3, 4, and 5. Survey dates were June 16, 28, July 12, 27, Aug. 10, 23, and Sept. 12. Due to differences in planting dates, all plantings were not sampled on every survey date.

RESULTS

Experimental Field Surveys

Expression of leafminer numbers per individual onion leaf were extremely variable due to changes in leaf area with plant maturation. Thus, individual leaf areas of sampled leaves were estimated and insect densities expressed as the number of individuals per unit area. Densities of live *Liriomyza* larvae peaked twice in the untreated control on June 21 and July 27 (Fig. 1a). Densities in the methomyl treatment were not significantly different from those of the untreated control except on June 21 when larval densities in the methomyl treatment were significantly lower than the untreated control. Densities of live larvae were significantly higher in the bean-bordered onions as compared with the other treatments on and following June 28. Less than 10 externally parasitized leafminer larvae were observed in the onion foliage throughout the study. Leafminer larval densities in the beans bordering the onions peaked on June 21 and July 13 (Fig. 1b). Externally parasitized larvae decreased after the live larval densities were reduced.

In all replicates, *L. huidobrensis* was the predominant leafminer species reared to the adult stage from collected onion foliage (Fig. 2a, b, c). Early in the study, *L. trifolii* was reared out in low numbers and later decreased to zero. Few adults of *L. sativae* were reared from the onion foliage. Densities of reared *L. huidobrensis* adults peaked twice in the untreated control (Fig. 2a). The major parasite species found in the untreated onion foliage were *H. circulus* (52.2%) and *C. parksi* (44.0%). The only other parasites reared were *D. intermedius* (3.8%) and *Diglyphus begini* Ashmead (>0.1%). Early in the study, *H. circulus* was the most numerous parasite in all the treatments (Fig. 2a, b, c). Numbers of *L. huidobrensis* adults and parasites reared from the methomyl treatment were not significantly different from the untreated control. *L. huidobrensis* densities were significantly higher in the bean-bordered onion replicates on most dates. Densities of *H. circulus* in the bean-bordered replicates were highest and peaked on the same date as those in the other treatments. *C. parksi* densities were highest in the bean-bordered onions and peaked on July 13 when *C. parksi* densities in the other treatments were near zero.

L. sativae and *L. trifolii* were the first and second most abundant leafminer species in the bean borders (Fig. 3a). *L. trifolii* densities were ca. 3 times less than those of *L. sativae* initially and steadily decreased through the study. Few adults of *L. huidobrensis* were reared from the foliage. Total parasitism, expressed as the sum of all parasites reared, peaked on June 21 and July 27. Following each peak, *L. sativae* decreased significantly (Fig. 3a). *D. begini* (44.1%) was the most abundant parasite reared from the leafminer infested bean foliage. Its density peaked on July 27 (Fig. 3b). The next most abundant parasite was *C. parksi* (29.5%). Its densities

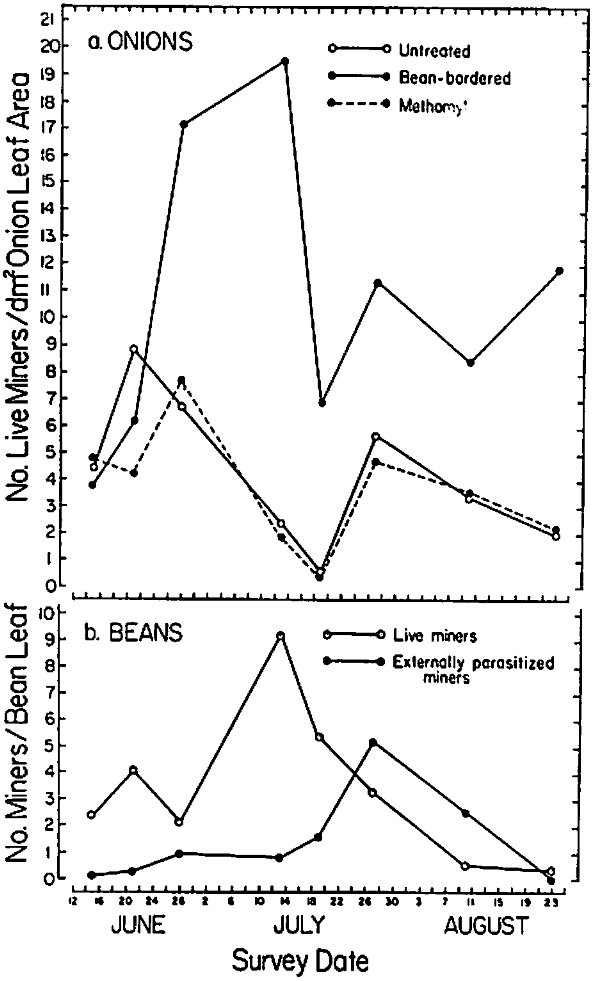

FIGURE 1. Mean densities of live and externally parasitized *Liriomyza* larvae recorded from various onion treatments (a) and bean borders (b).

were followed by those of *D. intermedius* (16.9%), *H. circulus* (6.0%), *Chrysonotomyia formosa* (Westwood) (1.5%), *O. dissitus* (0.8%), *Hemiptarsenus semialbiclavus* (Girault) (0.6%), and *G. hunteri* (0.4%).

The mean leaf area per onion plant steadily increased in all treatments until Aug. 9 when it peaked, decreasing afterwards (Fig. 4). Leaf areas in the bean-bordered onions were greater than those in the other treatments from June 21 through July 19 being significant on July 12. Leaf areas of the methomyl-treated onions were smaller than all other treatments from June 28 through July 26. Differences in leaf area per onion plant were visibly different between the bean-bordered onions and the other treatments early in the study. Initially, the bean-bordered onions were lush compared with the other treatments which appeared water-stressed. Although all treatments were irrigated equally, the bean borders may have acted as wind breaks, reducing either or both plant transpiration rates and water evaporation rates from

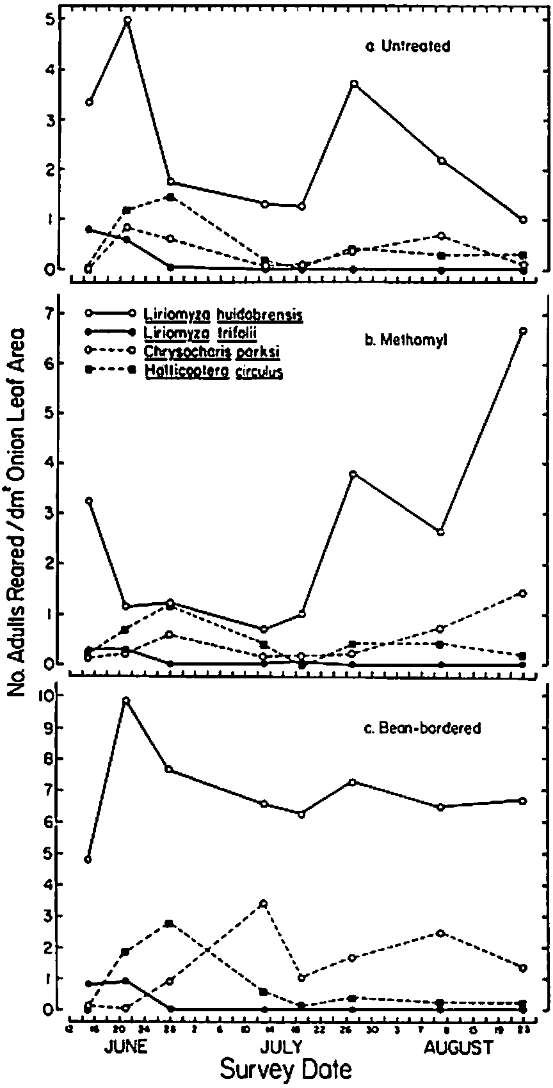

FIGURE 2. Mean number of *Liriomyza* adults and parasites reared from the untreated control (a), methomyl treated onions (b), and the bean-bordered onions (c).

the soil within the bean-bordered onion replicates. Significantly higher *L. huidobrensis* densities in the bean-bordered onions may have resulted from the greater attractiveness of the lush onion foliage to ovipositing females.

With respect to onions greater than 6 cm in width, the untreated control and methomyl treatment produced 33.92 metric tons of onions/ha as compared to the bean-bordered onions which produced 32.15 metric tons/ha. No significant differences were found in onion yield between the treatments. This includes the various onion size categories examined, number produced and onion yield weight per ha.

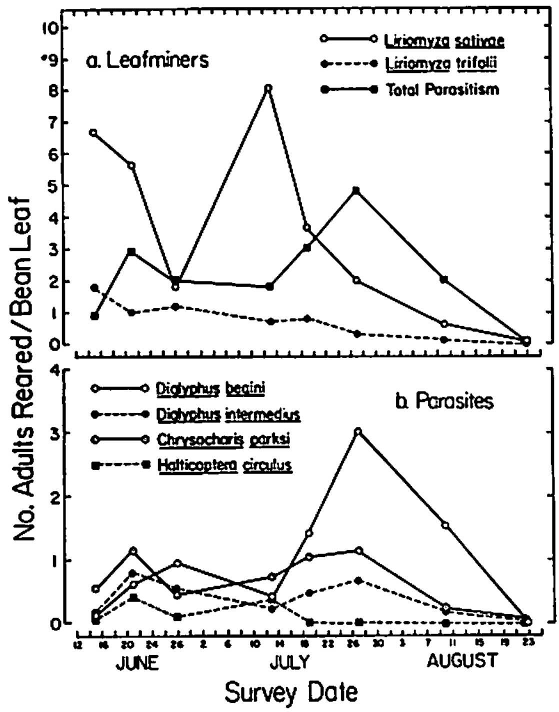

FIGURE 3. Mean numbers of *Liriomyza* adults (a) and parasites (b) reared from beans bordering onion replicates.

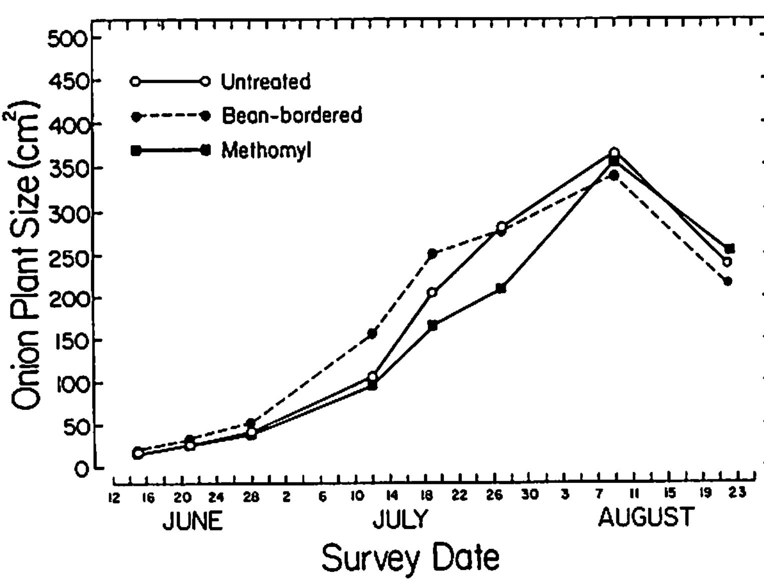

FIGURE 4. Mean leaf areas per onion plant recorded from various onion treatments.

Commercial Field Survey

Densities of live *Liriomyza* larvae recorded in the commercial onion plantings were generally less than 9 live larvae/dm^2 leaf area, except in Fields 2 and 4 on June 28 and July 12, respectively (Table 1). *L. huidobrensis* was the predominant agromyzid species reared from the onion foliage (Table 2). Initially, Field 3 had high densities of *L. trifolii* on July 27, but these subsided as the season progressed. *C. parksi* was found predominantly at altitudes lower than 634 m and did not occur at 1036 m (Table 2). *H. circulus* was the only parasite reared from foliage collected at 1036 m.

DISCUSSION

The experimental field studies and commercial plantings survey indicate that *L. huidobrensis* is the predominant agromyzid species infesting onions in the Kula area. *L. trifolii* is an occasional pest of onions and this may be related to the alternate host crops located in an area. No significant reductions in yield were observed with long term high densities of live leafminer larvae infesting onion plants as compared with untreated controls. Population densities of *L. huidobrensis* larvae in commercial plantings were generally below density levels observed in the experimental studies and were probably not economically significant. Unexpected growth enhancement in the onions adjacent to the bean borders resulted in high leafminer densities probably due to increased attractiveness of succulent host plants. It may also be noted that *L. huidobrensis* adults did not originate from the beans which were predominantly infested by *L. sativae.*

The major parasite species attacking *L. huidobrensis* in the onions were *H. circulus* and *C. parksi.* Densities of the leafminer parasites *D. begini* and *D. interme-*

TABLE 1. Mean leaf areas of foliage sampled and densities of live *Liriomyza* larvae found infesting 5 commerical onion plantings in the Kula area of Maui, Hawaii.

Survey Date 1983	Field No. 1	2	3	4	5
		Mean Area (dm^2) / Leaf Sampled			
16 June		0.13			0.21
28 June		0.23			0.21
12 July	0.41	0.59		0.25	0.67
27 July	0.60	0.89	0.28	0.28	1.10
10 August	0.70	1.01	0.79	0.84	1.25
23 August	0.60		0.88	0.93	1.00
12 September			0.89	0.78	
		Mean No. Larvae / dm^2 Leaf Area			
16 June		5.8			0.0
28 June		12.3			7.3
12 July	3.9	2.2		22.9	3.3
27 July	6.0	0.9	8.2	10.2	2.9
10 August	1.3	1.9	1.2	0.6	0.6
23 August	0.4		0.2	0.0	0.8
12 September			0.2	0.1	

dius were significantly lower in the onion plantings although they were present in high densities in the bean borders. In addition, four parasite species present in the beans were not found in the onions. These results suggest that either the parasites do not orient towards onions as a host habitat or that *L. huidobrensis* is an unsuitable host. Lange et al. (1957) reported *D. begini* and *D. intermedius* parasitizing *L. huidobrensis* on spinach. Thus, orientation of these species towards the onion habitat may be poor. Further studies are necessary to determine these relationships.

Although very little can be said concerning the effectiveness of using bean borders to augment leafminer parasitization in onions, these results indicate a need for greater understanding of the biologies and host plant preferences of the various leafminer parasites for their insect hosts and crop habitats. Advances in augmentation methodologies for increased leafminer parasitization will be impeded without a thorough knowledge of how parasite preferences vary with respect to hosts, crop ecosystem, and locality.

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TABLE 2. Numbers of *Liriomyza huidobrensis, L. trifolii, Chrysocharis parks,* and *Halticpatera circulus* reared from onion foliage collected at 5 commercial plantings in the Kula area of Maui, Hawaii.

Field No.	Elevation (m)	Species Reared	Survey Date: June 16	June 28	July 12	July 27	August 10	August 23	September 12
1	503	*L. huidobrensis*	-	-	16	34	21	3	-
		L. trifolii	-	-	0	0	1	0	-
		C. parksi	-	-	4	4	1	2	-
2	576	*L. huidobrensis*	3	21	11	9	34	-	-
		C. parksi	0	9	2	1	4	-	-
3	634	*L. huidobrensis*	-	-	-	14	0	7	0
		L. trifolii	-	-	-	13	0	1	0
		C. parksi	-	-	-	2	0	0	0
4	678	*L. hiudobrensis*	-	-	4	22	7	2	1
		L. trifolii	-	-	0	0	1	0	0
		C. parksi	-	-	0	1	1	0	1
		H. circulus	-	-	5	4	1	0	0
5	1036	*L. huidobrensis*	6	26	24	42	19	6	-
		H. circulus	0	6	5	2	5	4	-

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